

What is claimed is:

1. An insulating tube comprising:
 - a underlying insulating film;
 - 5 a first sidewall insulating film disposed on the underlying insulating film;
 - a second sidewall insulating film disposed on the underlying insulating film, opposite to the first sidewall insulating film so as to provide a cavity between the first and second sidewall insulating films having the same height as the first sidewall insulating film; and
 - 10 an upper insulating film provided over the first and second sidewall insulating films.
- 15 2. The insulating tube of claim 1, wherein the upper insulating film includes:
 - a central beam laid over the first and second sidewall insulating films so as to seal an upper portion of the cavity;
 - 20 a first side-beam disposed on the first sidewall insulating film having the same height as the central beam; and
 - 25 a second side-beam disposed on the second sidewall insulating film and having the same height as the first side-beam so as to sandwich the central beam with the first side-beam.

3. The insulating tube of claim 1, wherein a bottom portion width of the first sidewall insulating film contacting the underlying insulating film is narrower than a middle portion width of the first sidewall insulating film spaced from the underlying insulating film and a bottom portion width of the second sidewall insulating film contacting the underlying insulating film is narrower than a middle portion width of the second sidewall insulating film spaced from the underlying insulating film.
4. The insulating tube of claim 1, wherein a top portion width of the first sidewall insulating film contacting the upper insulating film is narrower than a middle portion width of the first sidewall insulating film spaced from the upper insulating film and a top portion width of the second sidewall insulating film contacting the upper insulating film is narrower than a middle portion width of the second sidewall insulating film spaced from the upper insulating film.
5. The insulating tube of claim 3, wherein the bottom portion width is 10 nm to 30 nm narrower than the middle portion width.
6. The insulating tube of claim 4, wherein the top portion width is 10 nm to 30 nm narrower than the middle portion width.

width.

7. The insulating tube of claim 2, wherein the width of the first side-beam is narrower than the width of the first sidewall insulating film and the width of the second side-beam is narrower than the width of the second sidewall insulating film.
5
8. A semiconductor device comprising;
10 a substrate;
 a first interlayer insulating film disposed on the substrate;
 a underlying insulating film disposed on the first interlayer insulating film;
15 a first sidewall insulating film disposed on the underlying insulating film;
 a second sidewall insulating film disposed on the underlying insulating film, opposite to the first sidewall insulating film so as to provide a cavity between the first and second sidewall insulating films having the same height
20 as the first sidewall insulating film;
 an upper insulating film provided over the first and second sidewall insulating films; and
 a wiring disposed around the first and second
25 sidewall insulating films.

9. The semiconductor device of claim 8, wherein the wiring

includes a wiring core disposed around one of the first and second sidewall insulating film and a barrier metal disposed around the wiring core.

5 10. A method of manufacturing a semiconductor device comprising:

depositing a first interlayer insulating film on a substrate;

10 depositing a underlying insulating film on the interlayer insulating film;

depositing a porous-low-k film on the underlying insulating film;

depositing a low-k film on the porous-low-k film;

15 etching the porous-low-k film and the low-k film so as to provide a groove and changing chemical compositions of a residual part of the porous-low-k film and a residual part of the low-k film, and forming first and second sidewall insulating films at sidewall portions of the residual porous-low-k film, and forming first and second 20 side-beams at the sidewall portions of the residual low-k film; and

removing a central portion of the residual porous-low-k film formed between the first and second sidewall insulating films.

25

11. The method of claim 10, wherein the porous-low-k film and the low-k film are etched by a chemical solution

solution.

12. The method of claim 10 includes evaporating moisture
the porous-low-k film and the low-k film.

5

13. The method of claim 10 includes burying a pair of
wirings around the first and second sidewall insulating
films.

10 14. The method of claim 13, wherein the pair of wirings
is formed by depositing a barrier metal on the surface
of the groove and depositing a wiring core on the barrier
metal.

15 15. The method of claim 13, further comprising
forming a second insulating film on the wiring;
forming a upper groove configured to penetrate the
second insulating film; and
burying a upper wiring on the upper groove.

20

16. The method of claim 10, wherein the groove is formed
by fluorine gas.

17. The method of claim 11, wherein a hydrofluoric acid
25 is the chemical solution.

18. The method of claim 11 wherein a buffered

hydrofluoric acid is the chemical solution.

19. The method of claim 11, wherein the cavity is formed
by providing moisture to the porous-low-k film with
5 water vapor.

20. The method of claim 11, wherein the cavity is formed
by providing moisture to the porous-low-k film with
hydrofluoric acid.

10